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# SF PHOSPHATES LIMITED COMPANY

# TAILINGS STORAGE FACILITY EXPANSION

# PLAN OF OPERATIONS

July 24, 1998

Prepared for:

SF Phosphates Limited Company
9401 North Highway 91
Vernal, Utah 84078-7802

Submitted to:

Bureau of Land Management
Vernal Field Office
Vernal, Utah

Prepared by:

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**SF PHOSPHATES LIMITED COMPANY**
**TAILINGS STORAGE FACILITY**
**EXPANSION**
**PLAN OF OPERATIONS**

Table of Contents

- Table of contents continued -



## LIST OF FIGURES



## LIST OF APPENDICES

# PLAN OF OPERATIONS
# FOR THE
# SF PHOSPHATES LIMITED COMPANY
# TAILINGS STORAGE FACILITY

SF Phosphates Limited Company (SF Phosphates) operates a phosphate mining and milling operation north of Vernal, Utah. Phosphate slurry is then transported by a 96-mile pipeline to a fertilizer processing plant located near Rock Springs, Wyoming. The projected life of the mine is on the order of 100 years. Preparation of the phosphate ore at the mine site results in the production of tailings which are currently stored in a facility specifically designed for this purpose. The mining and processing operation employs approximately 125 people.

This Plan of Operations (POO) is for the expansion of the existing Tailings Storage Facility (TSF). It is being submitted in compliance with the BLM regulations for mining operations on public lands under the general mining law (43 CFR 3809). SF Phosphates has patented claims on the land where the existing TSF is located. However, 35 acres of BLM administered land will be impacted by the proposed raise of the existing tailings dam and subsequent innundation with tails. This POO addresses that impacted area.

An expansion of the TSF is necessary because it is estimated that the current facility will be filled to maximum capacity by the year 2006. Since the anticipated life of the mining operation extends well beyond this, additional tailings storage capacity must be developed. Expansion will occur as seven 15 to 18 ft. lifts spread over the next 35 to 40 years. Continued construction on the existing dam will allow phosphate production to continue with minimal impact to the environment. At the currently planned production rates, the proposed raise design would provide enough tailings capacity for about 44 more years of operation. Tailings storage at the "B" site or other remote areas may be needed in the distant future.

## 1.0 APPLICANT INFORMATION

### 1.A. Claim Information

SF Phosphates has filed a block of Mill Site claims located in Sections 5 & 6,T.3 S., R.22 E and Section 1, T.3 S., R.21 E. These claims are located on federal land administered by the Vernal Field Office of the Bureau of Land Management (BLM). In Appendix A, a table titled "Mining Claims Summary" shows the mill site claim names and the BLM serial numbers.

### 1.B Individual Completing Application

This Plan of Operations is submitted by M.A. Weaver, Mine Manager on behalf of SF Phosphates.

## 1.C Business Address and Telephone

The business address for SF Phosphates is:

SF Phosphates Limited
9401 North Highway 191
Vernal, Utah 84078
Telephone: (435) 781-3348
Fax: (435) 789-2944.

## 1.D Corporation Information

The property was initially developed by the San Francisco Chemical Company in 1958. It was purchased by Stauffer Chemical Company in 1968 and then by Chevron Resources Company in 1981. In April, 1992, the mine, pipeline, and fertilizer plant were purchased by J.R. Simplot Company, a privately held agribusiness company in Boise, Idaho, and Farmland Industries, Inc., an agricultural food marketing and manufacturing cooperative in Kansas City, Missouri. SF Phosphates Limited Company was formed as an independent company through this joint venture.

## 1.E. Authorized Field Representative Information

The authorized field representative and daily contact is Ron Ryan at the address and phone number listed above.

# 2.0 CURRENT OPERATIONS

## 2.A. Location and Project Area Disturbance

The location of the existing SF Phosphates mine and concentrate production plant is approximately 11 miles north of Vernal, Uintah County, Utah (Figure 1, Location Map). This Plan of Operations is for the portion of the expansion of the existing SF Phosphates TSF onto approximately 35 acres of public land administered by the BLM. The existing TSF is located adjacent to the SF Phosphates concentrator (Figure 2, Tailings Storage Facility Map). The permitted area of the current TSF is 365 acres. The legal location of this feature is:

NE/4, SW/4 SE/4, Section 36, T. 2 S., R. 21 E.
NW/4, NE/4, Section 1, T. 3 S., R. 21 E.
SE/4, SW/4, Section 31, T. 2 S., R. 22 E.
NE/4, NW/4, Section 6, T. 3 S., R. 22 E.
SW/4, Section 32. T.2 S., R. 22 E.
NW/4, Section 5, T. 3 S., R. 22 E.

The entire property covers an area of approximately 23 square miles on the south slope of the Uintah Mountains in northeast Utah. The elevation of the property is approximately 6,000 feet. Access to the property is via Highway 191 which bisects the property. The perennial Big Brush Creek flows through the property immediately north of the concentrator in a deep gorge and leaves the property east of the tailings dam. Prominent nearby features include Red Fleet Reservoir on Big Brush Creek approximately 2 miles east of the property boundary; Steinaker Reservoir approximately 4 miles south; and Ashley National Forest immediately north and west of the property.

## 2.B. Mining Operations

Approximately 3.8 million tons of phosphate ore are mined annually at the mine. Topsoil is removed from the area to be mined and is placed on previously mined areas which have been prepared for reclamation or it is stored until such areas are ready to receive topsoil. Following the removal of topsoil, overburden is blasted to loosen the material. This overburden material is then relocated to mined-out areas. Once the overburden is removed and the ore is exposed, the ore is blasted and loaded into trucks using shovels or front-end loaders. The ore is then trucked to a portable crusher and conveyor where it is crushed to minus 10 inches and then transported to a 110,000 ton surge pile. Conveyors then transport this product to a semi-autogenous grinding (SAG) mill. The ground ore slurry from the SAG mill is then pumped through a 1.5 mile long pipeline to the concentrator facility (mill).

## 2.C. Processing Operations

At the mill, the ore slurry is ground further in a ball mill in closed circuit with hydrocyclone classifiers. Clay fines from the classifiers are considered tailings and are pumped to the TSF. The coarser material from the classifiers is conditioned in mixer tanks with flotation reagents including: diesel oil, fatty acid, and polymers and then processed through a bank of flotation cells. In the flotation cells the phosphate mineral grains are separated from the barren sand which is pumped to the TSF tailings dam cyclones. The phosphate mineral grains are removed from the top of the flotation cells and pumped to a thickener where the density of the slurry is adjusted before being pumped through a 95-mile long slurry pipeline to a fertilizer plant in Rock Springs, Wyoming. Clarified water from the TSF is reclaimed in a barge-mounted pump and returned to the grinding facility for reuse.

## 2.D. Tailings Storage Facility (TSF)

The Tailings Storage Facility (TSF) includes the both dam(s) and the impoundment of water and tailings. Two types of tailings slurry produced in the mill are transported separately to the TSF for disposal. Fine tailings slimes are discharged by gravity flow to the northeast area of the tailings impoundment. Coarser tailings from the flotation cells are typically pumped to the crest of the tailings dam, are cycloned there and discharged along the upstream face of the dam. The sand fraction of the cycloned tailings solids forms a 150 to 200-foot wide sand beach along the upstream face of the dam and the clay and silt slimes fraction flow to the western portions of the impoundment. Ultimately, all of the tailings will be discharged over the extended embankment.

Clarified tailings water is reclaimed from the west end of the impoundment at a barge-mounted reclaim pump to be recycled to the mill process. The supernatant pond covers much of the tailings surface. It is shallow over most of the tailings and attains its maximum depth in the western area of the impoundment near the reclaim barge. Water reclaimed from the TSF is reused in the grinding process. It is also used for transporting the phosphate concentrate to Rock Springs in the slurry pipeline.

When the concentrator first commenced operations in 1961, tailings slurry from the concentrator was piped to a tailings storage impoundment located behind a dam built of waste rock to an elevation of about 5915 feet in an ephemeral drainage immediately south of the concentrator. The first tailings storage facility was known as Tailings Pond No.1. In 1973 the capacity of the tailings storage was increased by construction of Tailings Dam No.2 which crossed two ephemeral drainages immediately south of Tailings Pond No.1. The initial Tailings Dam No.2 was built from mine waste rock to an elevation of approximately 5880 feet but was subsequently raised with three upstream lifts to a maximum elevation of 5,900 feet.

In 1985, Morrison-Knudsen Engineers, Inc. completed a final design for a major expansion of the TSF by raising the tailings dam (M-K, 1985). Beginning in 1986, both of the earlier tailings dams were covered with an earthfill dam that produced the combined tailings storage facility (TSF) that exists today. This dam was constructed in a downstream manner over both of the previous dams using soils and Moenkopi Formation rock borrowed from within the impoundment area.

The current dam crest is at an elevation of approximately 5952 feet and is planned to be raised to a final crest elevation of 5,970 feet in 2000 when its maximum height will be 268 feet. The downstream slope of the current tailings dam is approximately 2.5h:1v and its top width is approximately 140 feet. The overall length of the current dam is approximately 5,600 feet and the area of the tailings impoundment is approximately 326 acres. A 10-foot freeboard is maintained above the maximum elevation of the tailings at the upstream face of the tailings. At the current rate of tailings discharge, the capacity of the currently approved TSF will be consumed in about 2006. Therefore, additional tailings capacity will be necessary through raising the elevation of the tailings dam.

The existing tailings dam is constructed of compacted siltstone obtained from local borrow areas in the Moenkopi Formation. Seepage of tailings water through the dam is controlled with chimney drains, blanket drains, and collector drains that intercept seepage and direct it to the downstream toe of the dam. The downstream outlets of the three main collector drains are fitted with measuring devices to allow the seepage flow rates to be individually monitored. These outlets are located at the downstream toe of the dam in the bottoms of three main drainages crossed by the dam.

## 2.E Tailings Solids Characteristics

The chemical and mineralogic composition of the tailings solids is inert, non-hazardous and stable. Characteristics of the future tailings can be expected to be very similar to those which are being experienced in the current operations. Tailings are generally fine to very fine grain sediment mineral particles with very low concentrations of heavy metals or acid producing materials. These characteristics signify that this proposed facility is not likely to adversely impact human health or the environment.

Based on information collected by SF Phosphates from samples of tailings obtained in 1991 and 1996, the tailings solids are expected to have the physical characteristics described below:

| | | |
|---|---|---|
| Slurry Density | 50 | Percent Solids |
| Maximum Grain Size | 40 | Mesh |
| Minus 200 Mesh Solids | 90.5 | Percent |
| Pyrite | 1-2 | Percent |
| Quartz | 25-37 | Percent |
| Carbonates | 22-27 | Percent |
| Clays | 12-15 | Percent |
| Ca-Apatite | 27-30 | Percent |

The tailings deposited in the TSF are ground ore and water with small quantities of flotation reagents. The only source of waste entering the TSF is the S. F. Phosphates concentrator tailings and potential sewage from the concentrator buildings in the future.

Approximately 2,447,000 tons of ground ore are disposed of in the tailings pond annually. The fine tailings are low plasticity clay and silt with 95 - 100 % passing the No.200 sieve (Knight Piesold, 1997). The sand tailings are a silty sand with less than 20% passing the No. 200 sieve. The dry density of the tailings solids ranges from about 80 to 112 pcf. Various analyses have been conducted of the tailings solids between 1982 and 1997. These analyses indicate that the tailings are non-toxic, non-acid-forming, similar to natural soils in their chemical characteristics, and are not a significant potential source of ground water pollution. The specific analytical results for each sampling event are presented in the following narrative and tables.

In 1982, Chevron obtained 3 samples of tailings for EP Toxicity Tests. Results of these analyses are shown in Table 2-1. These data show that the tailings had very low concentrations of all the Resource Conservation and Recovery Act (RCRA) toxic metals as well as low concentrations of antimony, cobalt, manganese, nickel and zinc.

**Table 2-1 1982 EP Toxicity Results for Tailings Solids** (mg/l)

| Constituent | Reg. Level | Sample #1 | Sample #2 | Sample #3 |
|---|---|---|---|---|
| Arsenic | 5.0 | <.001 | .016 | .003 |
| Antimony | None | <.001 | <.001 | <.001 |
| Barium | 100.0 | .965 | 1.450 | .899 |

| Constituent | Reg. Level | Sample #1 | Sample #2 | Sample #3 |
|---|---|---|---|---|
| Cadmium | 1.0 | .004 | .002 | .007 |
| Chromium | 5.0 | .020 | .005 | .012 |
| Cobalt | None | <.001 | <.001 | <.001 |
| Lead | 5.0 | .133 | .095 | .006 |
| Manganese | None | .005 | .065 | .025 |
| Mercury | 0.2 | .0003 | .0002 | .0010 |
| Selenium | 1.0 | .005 | .002 | <.001 |
| Silver | 5.0 | .005 | .004 | <.001 |
| Nickel | None | .015 | .017 | .055 |
| Zinc | None | .445 | .669 | .775 |

In 1991, S. F. Phosphates sampled the tailings solids and the tailings water in a number of locations. The tailings solids were analyzed for pH, TCLP and total metals. The analytical results for the 1991 tailings solids metals analyses are shown in Table 2-2. These results indicate that the metal concentrations in the tailings are within the range typically found in soils of the western United States (EPA, 1986)

**Table 2-2 1991 Total Metals Results for Tailings Solids** (mg/kg)

| Parameter | SB-1 | SB-2 | SB-3 | SB-4 | SB-5 | SB-6 | SB-7 | SB-8 | Standard |
|---|---|---|---|---|---|---|---|---|---|
| pH | 7.8 | 7.8 | 7.5 | 7.6 | 7.2 | 7.2 | 7.5 | 7.3 | |
| Phosphate | 12.8 | 16.1 | 15.9 | 1.7 | 18.5 | 13.5 | 12.1 | 10.4 | |
| Sulfate | 137 | 285 | 1720 | 5860 | 482 | 2740 | 303 | 8140 | |
| Fluoride | 5.8 | 5.6 | 5.4 | 2.1 | 1.8 | 9.6 | 21.6 | 2.7 | |
| Silver | <1.0 | 1.1 | <1.0 | 1.8 | <1.0 | <1.0 | <1.0 | <1.0 | |
| Arsenic | 12.1 | 10.8 | 7.5 | <1.0 | 2.7 | 8.1 | 11.1 | 8.6 | 6 |
| Barium | 358 | 279 | 197 | 77.3 | 152 | 152 | 265 | 135 | 580 |
| Beryllium | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | |
| Cadmium | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | 0.06 |
| Chromium | 693 | 866 | 431 | 14.1 | 11.4 | 13.4 | 482 | 53.4 | 100 |
| Copper | 10.1 | 6.6 | 5.4 | 3.8 | 13.1 | 10.4 | 8.9 | 9.6 | 20 |
| Mercury | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | .083 |

| Parameter | SF-1 | SF-2 | SF-3 | SF-4 | SF-5 | SF-6 | SF-7 | SF-8 | Normal* |
|---|---|---|---|---|---|---|---|---|---|
| Nickel | 35.9 | 30.8 | 21.0 | 3.7 | 10.9 | 11.1 | 29.7 | 17.4 | 40 |
| Lead | 6.1 | 6.0 | 3.7 | 3.0 | 6.5 | 10.6 | 5.9 | 6.4 | 10 |
| Antimony | <3.0 | <3.0 | <3.0 | <3.0 | <3.0 | <3.0 | <3.0 | <3.0 | |
| Selenium | 3.7 | 5.3 | 2.6 | <1.0 | <1.0 | <1.0 | 2.9 | <1.0 | 0.5 |
| Thorium | <1.0 | <2.0 | 1.9 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 | |
| Zinc | 96.7 | 83.4 | 52.6 | 15.1 | 36.3 | 3-.6 | 88.5 | 50.0 | 50 |

* Common concentration in soil materials in Western U.S. (EPA, 1986)

Samples of tailings solids were analyzed for TCLP parameters in 1991. These results are shown in Table 2-3 and indicate that the tailings did not exceed any of the regulatory levels for the RCRA hazardous toxicity waste characteristics.

**Table 2-3 1991 TCLP Results for Tailings Solids** (mg/l)

| Parameter | SE-1 | SE-2 | SE-7 | SE-9 | Reg. Level |
|---|---|---|---|---|---|
| Arsenic | <0.01 | <0.01 | <0.01 | <0.01 | 5.0 |
| Barium | 0.44 | 0.38 | 0.48 | 0.51 | 100 |
| Cadmium | <0.005 | <0.005 | <0.005 | <0.005 | 1.0 |
| Chromium | <0.01 | 0.03 | 0.01 | 0.01 | 5.0 |
| Lead | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 |
| Mercury | <0.005 | <0.005 | <0.005 | <0.005 | 0.2 |
| Selenium | 0.06 | <0.03 | 0.04 | 0.05 | 1.0 |
| Silver | <0.01 | <0.01 | <0.01 | <0.01 | 5.0 |
| Pesticides | ND | | ND | ND | Varies |
| Semi-Vols | ND | | ND | ND | Varies |
| Volatiles | ND | ND | ND | ND | Varies |

In 1997 Golder Associates analyzed samples of tailings solids for use as plant growth medium. These results are shown in Table 2-4. These data indicate that the tailings solids have neutral pH, are not saline, and do not exhibit levels of soluble metals that will be phytotoxic. They are deficient in some plant nutrients.

**Table 2-4 1997 Plant Nutrients Results for Tailings Solids**

| Parameter | Sand 1 | Sand 2 | Sand 3 | Slime 1 | Slime 2 | Slime 3 | Critical Value† |
|---|---|---|---|---|---|---|---|
| pH | 7.2 | 7.0 | 7.1 | 7.2 | 7.2 | 7.2 | <5.0 or >8.5 |
| EC | 1.79 | 2.63 | 2.20 | 2.65 | 2.71 | 2.62 | <8 |
| SAR | 0.38 | 0.31 | 0.14 | 0.43 | 0.46 | 0.44 | >10 |
| Phosphate | 3.80 | 2.54 | 2.20 | 14.8 | 12.5 | 13.5 | <7 |
| Potassium | 94.0 | 87.0 | 68.0 | 82.0 | 84.0 | 82.0 | <120 |
| Nitrate | 1.24 | 1.04 | 0.92 | 0.74 | 0.50 | 0.48 | <10 |
| Copper | 0.24 | 0.34 | 0.32 | 0.46 | 0.46 | 0.46 | None |
| Lead | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | None |
| Arsenic | 0.44 | 0.36 | 0.21 | 0.45 | 0.44 | 0.46 | None |
| Boron | 0.17 | 0.24 | 0.13 | 0.20 | 0.22 | 0.23 | <0.5 or >5 |
| Selenium | 0.02 | 0.02 | <0.02 | 0.02 | 0.02 | 0.02 | >0.1 |
| Molybdenum | 0.66 | 0.71 | 0.73 | 0.66 | 0.63 | 0.71 | 0.5 - 1.0 |
| Zinc | 0.46 | 1.48 | 5.10 | 0.64 | 0.60 | 0.62 | <1.0 |

† Values above which phytotoxicity may occur and below which deficiencies may result.
* Elemental results are in ppm plant available (soluble) concentrations.

Golder Associates also analyzed samples of tailings sands and slimes for acid-base accounting testing in 1997. The results of these tests is shown in Table 2-5. These data show that the tailings are not acid generating and are strongly neutralizing.

**Table 2-5 1997 Acid-Base Accounting Results for Tailings Solids**

| Sample | Carbonate (percent) | Total Sulfur (percent) | Acid Potential (t/1000t)* | Neut. Potential (t/1000t)* | Acid Base Potential (Neut. Pot. - Acid Pot.) |
|---|---|---|---|---|---|
| Sand 1 | 12.4 | 0.93 | 29.1 | 127 | 98.0 |
| Sand 2 | 12.1 | 1.89 | 59.0 | 125 | 65.5 |
| Sand 3 | 12.2 | 1.73 | 54.0 | 128 | 73.6 |
| Slime 1 | 13.8 | 1.22 | 38.1 | 136 | 97.5 |
| Slime 2 | 13.9 | 1.17 | 36.6 | 142 | 106 |
| Slime 3 | 13.7 | 1.21 | 37.8 | 106 | 98.8 |

*Tons of calcium carbonate per 1000 tons of material.

## 2.F. Tailings Water Characteristics

Samples of tailings water were obtained and analyzed in 1991 and 1996. These analyses indicated that the tailings water met all ground water standards and drinking water standards with the exception of TDS and sulfate which were above the secondary drinking water standards. The specific analytical results for each sampling event are presented in the following narrative and tables.

Tailings water samples were analyzed in 1991 for total metals, TDS, EC, P, $SO_4$, and F. The results of the tailings water analyses are shown in Table 2-6. These results indicate that the tailings water met all Utah Ground Water Standards under R317-6-2 for metals. It was slightly above the standard for fluoride in one sample (SW-2, 5.1 mg/l ) but the average fluoride concentration for the samples was within the standard.

**Table 2-6 1991 Analytical Results for Tailings Water** (mg/l)

| Parameter | SW-2 | SW-3 | SW-5 | SW-7 | G.W. Standard |
|---|---|---|---|---|---|
| pH | 7.86 | 7.88 | 7.87 | 7.84 | 6.5 - 8.5 |
| EC | 1130 | 1150 | 1190 | 1250 | NS |
| Phosphate | 1.60 | 0.14 | 0.07 | 0.17 | NS |
| Sulfate | 1390 | 1260 | 1560 | 1400 | NS |
| Fluoride | 5.1 | 3.3 | 3.4 | 3.2 | 4.0 |
| TDS | 1670 | 1760 | 1700 | 1730 | NS |
| Antimony | <0.03 | <0.03 | <0.03 | <0.03 | 0.006* |
| Arsenic | 0.004 | 0.003 | 0.002 | 0.003 | 0.05 |
| Barium | 0.05 | 0.05 | 0.05 | 0.07 | 2.0 |
| Beryllium | <0.005 | <0.005 | <0.005 | <0.005 | 0.004* |
| Cadmium | <0.005 | <0.005 | <0.005 | <0.005 | 0.005 |
| Chromium | <0.01 | <0.01 | <0.01 | 0.02 | 0.1 |
| Copper | <0.02 | <0.02 | <0.02 | <0.02 | 1.3 |
| Lead | <0.002 | <0.002 | <0.002 | <0.002 | 0.015 |
| Mercury | <0.0005 | <0.0005 | <0.0005 | <0.0005 | 0.002 |
| Nickel | 0.05 | 0.05 | 0.04 | 0.05 | 0.1* |
| Selenium | 0.003 | 0.003 | 0.003 | 0.002 | 0.05 |

| Parameter | SW-2 | SW-3 | SW-5 | [illegible] | G.W. Standard |
|---|---|---|---|---|---|
| Silver | <0.01 | <0.01 | <0.01 | <0.01 | 0.1 |
| Thallium | <0.002 | <0.002 | <0.002 | <0.002 | 0.002* |
| Zinc | 0.03 | 0.04 | 0.02 | 0.06 | 5.0 |

* Not listed in R317-6-2 but are EPA MCLs

In 1996 S. F. Phosphates analyzed a grab sample of tailings water for full-spectrum chemistry. The results of these analyses are shown in Table 2-7. The results of these analyses indicate that none of the analyses exceeded primary drinking water standards. Both TDS and sulfate exceeded the secondary drinking water standards. Iron and phosphorous slightly exceeded the water quality standard for Big Brush Creek (Class 3A).

**Table 2-7 1996 Results for Tailings Water** (mg/l)

| Parameter | Result | Primary Drinking Water Standard | Secondary Drinking Water Standard | Utah Surface Water Standard |
|---|---|---|---|---|
| pH | 7.6 | 6.5-8.5 | NS | 6.5-9.0 |
| EC | 2380 | NS | NS | NS |
| Alkalinity | 112 | NS | NS | NS |
| Ammonia | 0.07 | NS | NS | 19.5 |
| Bicarbonate | 112 | NS | NS | NS |
| BOD (5 day) | 1 | NS | NS | 5 |
| Carbonate | <2 | NS | NS | NS |
| Chloride | 12 | NS | 250 | NS |
| Cyanide | <0.01 | 0.02 | NS | 0.022 |
| Fluoride | <1.0 | 4.0 | 2.0 | NS |
| Gross Alpha | 14 pCi/l | 15 pCi/l | NS | 15 pCi/l |
| Gross Beta | 25 pCi/l | Man-made only | NS | 50 pCi/l |
| Hardness | 1480 | NS | NS | NS |
| Nitrate as N | <0.02 | 10.0 | NS | 4 |
| Nitrate/Nitrite | <0.02 | 10.0 | NS | NS |
| Oil & Grease | <2 | NS | NS | NS |

| Parameter | Result | Primary Drinking Water Standard | Secondary Drinking Water Standard | Utah Surface* Water Standard |
|---|---|---|---|---|
| Phosphorus | 0.070 | NS | NS | 0.05 |
| Sulfate | 1480 | NS | 250 | NS |
| TDS | 2230 | NS | 500 | NS |
| Arsenic (total) | 0.003 | 0.05 | NS | 0.36 |
| Barium (total) | 0.022 | 2.0 | NS | NS |
| Calcium (diss.) | 405 | NS | NS | NS |
| Chromium (tot) | <0.02 | 0.1 | NS | 1.7 |
| Iron (dissolved) | 0.03 | NS | 0.3 | 0.02 |
| Iron (total) | 0.06 | NS | NS | NS |
| Magnesium (d) | 113 | NS | NS | NS |
| Selenium (total) | 0.003 | 0.05 | NS | 0.02 |
| Sodium (diss) | 41.2 | NS | NS | NS |
| Zinc (total) | 0.04 | NS | 5.0 | 0.12 |
| Volatiles (624) | ND | Varies | NS | NS |

* Class 3A

## 2.G. Geology

The TSF is located on the south flank of the Uinta Mountains where erosion has deeply incised south-dipping sedimentary rocks of Triassic and Permian age. Big Brush Creek, the nearest perennial surface water body to the TSF, flows through Big Brush Creek Gorge to the north of the TSF and passes within 2000 feet to the east of the existing dam. The proposed TSF lift will be constructed by up-stream methods and will not result in the TSF being closer to Big Brush Creek than it is at the present time.

The rocks in the TSF vicinity have been uplifted and gently folded by the uplift of the Uinta Arch to the north and by southeast striking secondary folds which form two sub-parallel southeast striking and plunging anticlines near the TSF. The uplift of the Uinta Arch has resulted in the sedimentary rocks beneath and adjacent to the TSF having an 8 to 10 degree dip to the south.

The surficial bedrock geology in the vicinity of the TSF is shown on Figure 3, Geology Map. The south and south-southeast dip of the sedimentary rocks in the area have resulted in younger rocks being exposed to the south of the TSF and older rocks exposed to the north. The bedrock formations exposed in the project vicinity range from the Pennsylvanian Weber Quartzite to the Triassic Moenkopi Formation. In addition, the Morgan Formation, which underlies the Weber Quartzite, while not exposed in the project vicinity, has been intercepted by deep water supply wells drilled by SF Phosphates and its predecessors. The upper Morgan Formation consists of interbedded sandstone, limestone and shale. The total thicknesses of the Morgan in the project vicinity is believed to be 1000 to 1400 feet.

The Weber Quartzite ranges in thickness from 1015 to 1275 feet and is comprised of medium-grained, cross-bedded sandstone and massively bedded, fine-grained quartzose sandstone. This formation is exposed north of the TSF, especially in deeper canyons and gorges.

The Permian Park City Formation overlies the Weber Quartzite. This formation ranges in thickness from 140 to 150 feet in the vicinity of the TSF and is comprised of two members: the basal phosphatic member which is comprised of 24 to 28 feet of hard, cherty, phosphatic mudstone with minor sandstone; and the overlying upper Park City Formation which is 110 to 130 feet in thickness and is made up of cherty and sandy dolomitic limestone interbedded with shale and fine-grained sandstone (Hood, 1976).

The Triassic Moenkopi Formation consists of a thin-bedded siltstone, fine-grained sandstone, and sandy shale and ranges from 820 feet to 1120 feet in thickness. Gypsum can be common in the Moenkopi and results in highly gypsiferous zones within the formation. The lower Moenkopi forms the bedrock beneath the TSF where it consists of thin-bedded, reddish brown siltstone and fine-grained sandstone with thin partings of weak, red, sandy shale and thin beds of light greenish-gray fine-grained sandstone (Golder, 1998).

Overlying the Moenkopi and cropping out to the south of the TSF are the Shinarump Conglomerate, a thin (1 to 60 feet thick) medium to coarse-grained sandstone with quartzite pebbles, and the Chinle Formation (approximately 260 feet thick) which is comprised of red, variegated shale in the lower two-thirds of the unit and sandstone with thin red shale interbeds in the upper one third of the formation.

The axis of a north-northwest-striking, south-plunging, low-amplitude anticline has been mapped a short distance to the north of the TSF. The absence of detailed geologic mapping in the Moenkopi prior to initial tailings deposition and the absence of sufficiently deep drill holes to the west, south or east of the TSF to identify correlative stratigraphic horizons make it difficult to determine that this fold is present in the Moenkopi beneath the TSF. No faults have been mapped or otherwise identified beneath or in the vicinity of the TSF (Figure 3). A northwest striking fault is believed to be coincident with Big Brush Creek Gorge north of the TSF; however, this fault would not intercept the TSF and if it does extend to the south, would lie several thousand feet east of the TSF dam.

## 2.H. Ancillary Facilities

Ancillary facilities located at the SF Phosphates mine operations include offices, warehouses, and shop complex. These facilities provide administrative, logistical, and maintenance functions necessary to the operations. Additional facilities used to transport the phosphate slurry from the mine to a processing plant located in Rock Springs, Wyoming, include a pumping system at the plant site with three 2000 horsepower pumps to pump the phosphate slurry through the 96-mile pipeline.

# 3.0 PLAN OF OPERATIONS - TSF EXPANSION

## 3.A. Proposed Project Area

The TSF is located on the south flank of the Uinta Mountains where erosion has deeply incised south-dipping sedimentary rocks of Triassic and Permian age. Big Brush Creek, the nearest perennial surface water body to the TSF, flows through Big Brush Creek Gorge to the north of the TSF and passes within 2000 feet to the east of the existing dam. The proposed TSF lift will be constructed by up-stream methods and will not result in the TSF being closer to Big Brush Creek than it is at the present time (see Figure 2, Tailings Storage Facility Map). Red Fleet Reservoir State Park is located approximately two miles east-southeast from the TSF.

## 3.B. Proposed Tailings Dam Raise

A design for the proposed modifications to the TSF has been prepared by Golder Associates (Golder, 1998). The existing tailings dam will be raised sequentially using an upstream construction method from the existing crest elevation of 5952 feet to 6060 feet, a total raise of 108 feet. Construction raises or lifts will occur approximately every 5 to 7 years until maximum dam height is reached. The first raise of 18 feet will finish the existing dam to its design crest elevation of 5970 feet. Six additional raises, each 15 feet in height, are proposed to follow. The overall downstream slope would remain at 2.5h:1v and crest width would vary from the current 140 feet to 50 feet at the 6060-foot elevation (Figure 4, Tailings Dam Cross Section).

The majority of the raised dam is proposed to be constructed with on-site Moenkopi siltstone material from a ridge within the proposed impoundment area. Borrow sources to the south have been reviewed and are not considered favorable at this time. If mineral material needs from public lands outside SF Phosphates' property are needed, they would be obtained through a contract sale under the 43 CFR 3600 regulations.

Seepage control in the proposed raise would be provided by the 150 to 200-foot wide cycloned sand beach deposited along the upstream face of the dam. This permeable sand zone would direct seepage downward to the internal drain system of the existing dam. This drain system would continue to function as in the past, directing the seepage to the three collector drains in the same three locations as the current operations.

At the currently planned production rates, the proposed raise design would provide enough tailings capacity for about 44 more years of operation.

### 3.C. Proposed Inundation Area

The proposed expansion of the TSF will encompass approximately 184 acres; 149 acres on SF Phosphates' property and 35 acres on the Mill Sites filed on public land. As shown on Figure 2, Tailings Storage Facility Map, the proposed final inundation is expected to be about at the 6050 foot elevation. For the mill site claims the actual area inundated, as well as supporting the southern edge of the dam, is considerably less than the total area of 35 acres. The tailings and/or water would accumulate on the southern edge of the impoundment a vertical distance of about 100 feet up the ridge from the existing tailings surface. The final tailings surface would still be at least 100 feet below the ridge line.

At this time, there are no roads within this very rugged public lands area and none are planned. In the future, a discharge pipeline from the mill could possibly be situated on the southern end of the tailings dam area. Currently there is a Utah Power & Light electric transmission line which crosses the tailings pond near the eastern side of Section 6. Studies are in progress to determine the required modifications to span the pond. It is possible that fewer support towers would be used for the transmission line and that only towers on SF Phosphates' property will be affected.. The relocation plan anticipates using the existing right-of-way and the grantee is not expected to relinquish their prior existing rights.

### 3.D. Hazardous Materials Management

No deleterious materials or wastes will be produced by these operations. Less than 10,000 pounds of any chemical(s) from EPA's Consolidated list of Chemicals Subject to Reporting Under Title III of the Superfund Amendments and Reauthorization Act (SARA) of 1986, and less the Threshold Planning Quantity (TPQ) of any extremely hazardous substance(s), as defined in 40 CFR 355, will be used, produced, transported, stored, disposed, or associated with the proposed operation. Vehicle and equipment fuel, lubricants, antifreeze and battery acid will be the only hazardous materials used or associated with the proposed notice level work. Risk of a release will be minimal because it would be cleaned up immediately and disposed of in approved manner.

### 3.E. Other Regulatory Permit Activities

The mill site claims for 35 acres south of SF Phosphates' property are included in the Red Mountain-Dry Fork Area of Critical Environmental Concern (ACEC). This complex was designated by the Vernal Field Office of the Bureau of Land Management (BLM) in the Diamond Mountain Resource Area (DMRA) Resource Management Plan and Record of Decision, (RMP/ROD)(BLM, 1994), Decision SEA01. Expansion of the TSF would occur below the ridgeline of Red Mountain on its north slope and would not be noticeable from the ACEC except from the top of the mountain looking down on all of SF Phosphates existing operations.

A further decision of the DMRA RMP/ROD, RD 32, establishes a Special Recreation Management Area (SRMA) to cover the ACEC complex. The Red Mountain Potential Recreation Area is listed within Level 2, Careful Management, which allows activities that do not detract from the resource values being protected.

There are some sensitive resources within the ACEC, in addition to recreational values. These include raptor nesting habitat, deer and elk winter habitat and visual resources. Cultural resources have been evaluated within the mill site claims, and there were no eligible sites located within the area to be inundated by the tailings. Also, there are no threatened, endangered, or sensitive plant issues known in the mill site claims area. Issues of this nature will be addressed as part of the Environmental Assessment process.

The Division of Oil, Gas and Mining has been apprised of these expansion plans and will be forwarded a copy of this POO for their review and comment. They currently hold the mining reclamation bond and will regulate additional bonding requirements as needed.

An application for a Ground Water Discharge Permit has been submitted to the Utah Division of Water Quality. Responses to that agencies' comments are currently being prepared.

The Division of Water Rights - Dam Safety is also reviewing the engineering specifications and drawings associated with this project. Responses to that agencies' comments are also currently being prepared.

The Division of Air Quality is reviewing an initial operating permit application for a Title V permit. Issuance is expected in early August, 1998.

## 4.0 RECLAMATION PLAN

The reclamation plan for the future closure of the TSF will incorporate direct seeding of the tailings solids. The proposed final revegetation program would include seeding a crop of grass directly into the tailings solids as soon as the water drains off and they can be accessed for seeding.

The outer slopes of the tailings dam will be seeded as necessary during the life of the TSF to reduce erosion of the slope. It is expected that this slope will be adequately revegetated at the end of the TSF operations and will not need to be further reclaimed.

A tailings sampling program was conducted in 1997 and Golder Associates reviewed the potential for the dried tailings sand and slimes to support a perennial vegetative cover (Golder, 1998). Direct seeding of the tailings solids is a very viable approach to reclamation based upon the following characteristics. The tailings analyses indicated that the tailings pH is neutral. No soluble metals were identified at concentrations which would result in plant phytotoxicity. Soluble salts activity was at acceptable concentrations and acid-base accounting results indicated the tailings are strongly neutralizing and will not become acidic. There were deficiencies of available boron, zinc, nitrogen, potassium, and organic matter.

The reclamation requirements of the Division of Oil, Gas and Mining and the Bureau of Land Management will be followed in the final closure of the TSF. The final closure requirements of the Utah State Engineer, Dam Safety Office, will be followed for drainage and monitoring of the impoundment and dam.

### 4.A. Statement of Reclamation Activities

SF Phosphates proposes to increase the authorized surface disturbances from 365 acres to approximately 548.5 acres. However, only 35 acres of this disturbance will occur on lands administered by the BLM. Most of this new disturbance will result from inundation of lands by impounded tailings.

It is the intention of SF Phosphates to reclaim this proposed expansion of the Tailings Storage Facility (TSF) to meet all federal and state requirements. Reclamation will be both concurrent, to the extent practical, and post use, following plans described herein. The reclamation approach and procedures outlined in this section were developed for the site-specific conditions of this area. The procedures are designed such that the disturbance areas are reclaimed to a productive use similar to the pre-mining land uses, and the reclaimed areas are visually and functionally compatible with the surrounding topography.
The conceptual reclamation plan described in this section has been prepared primarily by Golder Associates to provide the general framework for reclamation of the TSF. Given the long duration of this mining operation, SF Phosphates recognizes that the "state of the art" in reclamation may change significantly by the time the TSF is ready for reclamation. Also, changes in the beneficiation process and/or ore may result in a final tailings surface with different physical and chemical characteristics from those which currently exist. The methods and concepts presented in this section will likely be reevaluated and revised over the life of the project. Therefore, this plan will concentrate on identifying potential issues that may be encountered in reclaiming the tailings, and how these issues will be addressed.

This plan presents the current condition of the tailings, discusses potential issues related to closure, stabilization and revegetation of the TSF, and presents conceptual methods to accomplish closure. The preferred closure method must stabilize the tailings surface, provide a viable post-closure land use, be technically and economically feasible, and allow permanent "walk-away" closure. Three possible closure options were initially considered:

- wet cover
- soil cover
- direct revegetation

A wet cover would be difficult to maintain in the semi-arid climate conditions at the project. Net evaporation would require the artificial addition of water to maintain a wet cover. This would preclude "walk-away" closure. Therefore, a wet cover was not considered practical.

A soil cover is also not an option because soil resources in the project vicinity are sparse and poorly developed. Soil recovery operations would be extremely difficult because of the large natural variations in topography. At a minimum soil cover of 2 inches, approximately 161,000 cubic yards of soil would be required to cover the tailings surface at closure. Soil would need to be borrowed from undisturbed areas in the project vicinity, creating a large additional area of disturbance, or else would need to be imported from outside the project area. No soil sources in the area have been identified. Importing soil is considered logistically and economically unfeasible.

Direct revegetation is the most realistic alternative since soil properties of the tailings suggest that they are a good topsoil substitute. Currently, volunteer vegetation has been growing in areas where tailings have been exposed. Direct revegetation of phosphate tailings has also been successfully performed in the eastern U.S. The specific amendment requirements are a function of many factors. Therefore, an integral component of this plan is to develop reclamation techniques based on knowledge gained prior to closure through the evaluation of test plots constructed on-site.

The goal of reclamation is to return the tailings to a condition that is compatible with the proposed post-mining land uses of wildlife grazing and watershed protection. Specific goals are to:

* provide a stable surface which resists water and wind erosion
* provide wildlife habitat
* promote establishment of a stable vegetative community
* protect surface water and groundwater quality

Successful direct revegetation of the tailings surface can accomplish these goals.

## 4.B. Reclamation Schedule

The proposed TSF expansion will allow operations to continue through the year 2042. Reclamation activities will be performed concurrently, to the extent practical, and immediately after the operation ceases. An exact schedule is not possible to determine at this time since there will be many years of operational decisions which will affect such timing.

Final vegetation of the downstream face of the tailings dam will begin as soon as construction of each raise is completed. The timing of this activity will be adjusted so that seeding will take place during either the spring or late fall planting seasons to maximize probability of vegetative success. Revegetation of the tailings surface will occur when surface conditions permit and at the end of the useful life of the facility.

Test plots will also be established in order to gain experience in direct revegetation of the tailings surface. These plots are further described in Section 4.G.

## 4.C. Post-Mining Land Use

The proposed post-mining land use for the TSF expansion will be wildlife grazing and watershed protection.

## 4.D. Post-Mining Topography

During the final years of operation of the TSF, the tailings discharge points will be adjusted as necessary to produce a final grade on the tailings solids toward the north end of the tailings dam where a spillway channel will be excavated. This channel will be designed to comply with Utah State Engineer requirements and to drain the peak flow from the PMP falling in the watershed above the tailings dam. This channel will prevent any significant accumulation of meteoric water against the tailings embankment.

The outer slope of the tailings dam will be constructed at a 2.5h:1v overall slope and has been shown to be stable under static and dynamic conditions (Knight Piesold, 1997, Golder, 1998). Therefore, the outer slope of the tailings dam will not be regraded at the end of operations of the TSF. The revegetated face of the embankment will minimize erosion. By the end of operations, the upstream slope of the dam will almost be covered with a beach of tailings sand so the upstream slope of the dam will also not require regrading.

Reclamation of the proposed TSF will result in an area with less relief than the pre-mining topography for the area where tailings are deposited. The average grade of the reclaimed tailings surface will be on the order of about 0.5%. The reduced relief will result in several benefits to the area. The reclaimed site will experience less erosion and greater water retention resulting in improved vegetation for use by wildlife.

## 4.E. Potential Reclamation Issues

Several factors that are often the major concerns during reclamation of metal mines are not anticipated to be a problem for the SF Phosphates tailings. These include pH, which is neutral; metals, none of which were at phytotoxic levels; salts, which occur at acceptable levels; and, acid generation, which is not predicted to occur based on the strong acid neutralizing characteristics of the tailings. Many of the remaining issues are representative of the background conditions in the area and are not specifically related to the tailings. The factors which may complicate revegetation of the tailings are:

- N. P. K and O.M. deficiency
- potential salt accumulation over time (upward migration of soluble salts)
- wind erosion

* molybdenosis toxicity to animals
* arid climate
* available water holding capacity
* surface crusting

Past experience with older tailings disposal areas at the site has shown that natural revegetation occurs quite readily on the tailings surface. Therefore, it can be concluded that none of the factors listed above will likely prohibit successful reclamation of the tailings with direct revegetation techniques. Each of these factors, and how they can be addressed during a carefully planned and executed reclamation process, are discussed below.

**4.E.a Nutrient Status**

The tailings are currently not an ideal growth medium due to low concentrations of plant available N, P, K and low O.M. Little topsoil occurs in the area and so supplementation by topsoil borrow material is not likely to be an option.

Nitrogen's primary function is to encourage above-ground vegetative growth and regulate utilization of potassium and phosphorus. Phosphorus serves many functions in the development of plants. A few of the most important include:

* cell division
* flowering and fruiting
* plant maturation
* root development
* disease resistance

Of these, the most important is generally root development. Potassium is essential for photosynthesis, chlorophyll formation, disease resistance, and seed formation, as well (Brady 1974). O.M. affects plant germination and survival more indirectly through the modification of soil properties. O.M. improves veil 'properties by improving infiltration and moisture holding capacity, encouraging aggregation, buffering soil temperature, and increasing cation exchange capacity. O.M. is also necessary for the development of mycorrhizal roots (Harvey 1982) which are necessary for the survival of many plant species. O.M. has been demonstrated to be essential to revegetation of phosphate-mined lands (Brumwell and Carrier 1989).

As previously stated, topsoil in the area is poorly developed and scarce. Therefore, the proposed approach to stabilization of the tailings is to directly revegetate the tailings using ameliorative and adaptive procedures. Direct revegetation will be supplemented by the selective redistribution of salvaged soil, if available.

The ameliorative approach involves chemically altering the soils to correct factors which may limit plant growth. Based on soil analysis, a site-specific combination and application rate of low-cost waste materials and standard reclamation amendments are specified to accomplish the required soil modification. Major nutrient deficiencies can also be addressed by adding fertilizers to the amelioration mixture.

The adaptive approach involves identifying, specifying, and establishing plants that are ecotypically differentiated, or adapted and tolerant of, the site conditions. Laboratory plant tolerance testing methods can be used to rapidly and cost-effectively screen a large number of plants for their tolerance to the specific conditions found at the site. This method involves using Agar (a gelatinous growth medium) and growth media adjusted chemically to emulate the specific site conditions. Since a plant's germination and initial root growth response are indicative of its response to actual site conditions, species that are adapted to site conditions can be rapidly evaluated and selected.

#### 4.E.b Salt Accumulation

Soluble salts of sodium, calcium and magnesium are currently not available in concentrations which could limit plant growth. However, the tailings are currently inundated. During and following closure, the ponded water will be removed and the tailings will dry out. Arid regions are characterized by excessive surface evaporation and soluble salts may accumulate in the surface horizon. Given the fine texture of the slimes, the potential exists for accumulation of salts and formation of saline conditions. If a salt accumulation hazard is identified, salt tolerant species will be selected for use in the reclamation seed mix. However, the local Natural Resource Conservation Service (NRCS) office indicates that no saline soils have been identified in the vicinity of the project and it is not anticipated that salt tolerant species will be necessary.

#### 4.E.c Wind Erosion

The texture of the tailings surface is predominantly silt-sized particles. Silts are highly susceptible to wind and water erosion. The relatively gentle slope at closure should minimize water erosion concerns. However, wind erosion will be a concern as the surface dries out. Methods to control wind erosion include physical barriers to slow and break up wind velocity, surface roughening, and covering the soil surface with a synthetic sealant, organic matter, and/or coarse fragments. However, the most proven, efficient and cost effective method to control wind erosion is to rapidly establish vegetation on the surface.

#### 4.E.d Molybdenum

Molybdenosis is a disease which affects ruminants, particularly cattle and sheep, and can result in mortality. To date, no molybdenosis has been observed. Although none is expected, a monitoring program will continue. Since no livestock grazing is proposed for the closed TSF, there will be no risk to cattle and sheep. Deer and elk are also affected, but to a lesser degree than cattle and sheep. The disease is due to copper deficiency caused by a complex and poorly understood reaction between copper, molybdenum and sulfur. Generally, when molybdenum and sulfur levels are elevated and copper levels are low, molybdenosis may occur. Cu:Mo ratios in plant tissues of less than 2:1 have been shown to cause molybdenosis unless dietary copper levels exceed 13 to 16 ppm. Unfortunately, molybdenum uptake levels are difficult to predict and not well correlated to concentrations in soil. In addition, some species, particularly legumes, can accumulate molybdenum at concentrations well above soil concentrations. The laboratory analyses indicate the plant available Cu:Mo ratio in the tailings is currently less than 1:1. The tailings analyses indicated total molybdenum concentrations of 5 to 6 ppm. Barchad (1948) reported molybdenosis in soils with total molybdenum concentrations of 1.5-5.0 ppm. Therefore, test plots will be constructed to include collecting and analyzing plants for copper and molybdenum levels in plant tissues. If, laboratory analyses indicate Cu:Mo ratios in plant tissues are less than 2:1, several options are available. They include:

* choosing species which do not accumulate Mo
* managing the TSF to exclude cattle following closure
* using a fertilizer amendment that includes chelated copper to increase plant available copper

**4.E.e Arid Climate**

There has been no evidence of surface crusting on any of the older tailings at the site and none is anticipated. However, the arid climate and fine texture of the tailings could potentially result in the formation of a crust on the surface. If a crust were to form, it may act as a barrier to infiltration and further reduce available moisture for plants. The crust may also inhibit plant emergence following germination. Addition of organic amendments and mulch increase soil moisture and encourage the formation of stable soil aggregates which will minimize crusting and increase infiltration and plant available moisture.

## 4.F. Revegetation

**4.F.a Current Nutrient Status of Tailings**

The tailings impoundment currently covers approximately 326 acres. At closure the TSF will cover approximately 600 acres. Currently, the surface of the tailings includes a 200-foot wide beach area composed of loamy sands up gradient of the tailings embankment beach area. The remainder of the tailings contain slimes which have a silt loam texture. The slimes are currently saturated and covered by standing water. Six tailings samples (three sand and three slimes) were collected in January 1998 and analyzed for texture, nutrient status, plant available and total metals, and acid-base accounting. The results are presented in Tables 7 and 8 (Appendix B).

Laboratory results were reviewed to identify the potential for metal-induced toxicity or potential nutrient deficiencies. The analyses were compared to soil suitability criteria determined by reviewing published data from various sources. It should be noted that the criteria presented in Table 7 are guidelines only as there is considerable variation in the available literature. Actual effects of a given metal concentration will vary as a function of many factors, including plant species, soil pH, climate, and redox potential.

The laboratory results indicate the tailings are currently deficient in plant available nitrogen(N), potassium (K) and organic matter (O.M.). Cation exchange capacity is low due to the low percentage of clay and organic matter. The sandy loam tailings are deficient in phosphorus (P). The relative lack of plant available P in the sandy loam tailings may be explained by the X-ray diffraction (XRD) results, which indicate the dominant phosphate mineral is apatite, a calcium-phosphate mineral which binds phosphorous in insoluble (unavailable) forms. This deficiency is further complicated by the lack of organic matter, which would tend to increase the availability of phosphorus. Tailings pH (saturated paste) is neutral. No metals were identified at concentrations which could result in plant phytotoxicity. Plant available boron and zinc are at concentrations which could result in deficiencies. Molybdenum is present at slightly elevated concentrations. Soluble salts activity is currently at acceptable concentrations. Acid-base accounting (ABA) results (Table 8) indicate the tailings are strongly acid neutralizing.

**4.F.b Site Specific Revegetation Procedures**

At closure, the majority of the tailings surface will consist of slimes in a saturated condition. It is anticipated that it will take a number of years before the slimes have consolidated and drained to the point where reclamation equipment can operate on the surface. Therefore, as soon as an area is drained of standing water, a nurse crop of seed, fertilizer, mulch and tackifier will be sprayed or aerially-applied (by airplane or helicopter) An alternative, which will be investigated during the mine life, is to hydraulically apply amendments and fertilizer by mixing it into the final stages of tailings deposition. The fertilizer and mulch rates will be determined based on nutrient analysis of samples collected near the end of the mine life and information gained through revegetation test plots performed during operations.

**4.F.c Reclamation Seed Sources**

Reclamation species mixtures will be developed for each area prior to closure. The species and application rates will be determined based on results of test plots and nutrient testing of the tailings prior to reclamation. If available at the time of reclamation, seed will be purchased from commercial suppliers. Seed will be developed from stocks that are adapted to the moisture regime and elevation of the site. If desired species are not commercially available, commercial suppliers can collect seed from adapted plants and produce the necessary quantity of seed if given a 2- to 3-year lead time. Ideally, parent stock should be collected from the project area. If sufficient sources are not available near the project, seed sources will be collected from sites with similar elevation and moisture regimes. Woody species will be planted as bare-root or containerized seedlings.

**4.F.d Potential Revegetation Species**

Tables 9 through 12 (Appendix B) present potential species for inclusion in the final seed mix. The four lists include potential species for the following areas/stages:

* slimes nurse crop
* slimes final crop
* sand beach
* spillway pool

**4.F.e Slimes Nurse Crop Species**

The slime nurse crop species were selected based on their tolerance to silt and clay textures and average annual precipitation of 15 inches or greater, corresponding to the period immediately following the end of tailings deposition when the tailings will still be wet. The slimes nurse crop will be seeded, probably by aerial means, as soon as standing water no longer remains in the impoundment. It's purpose is to provide immediate stabilization of the tailings surface, and to promote natural succession by increasing evapotranspiration and imparting shade and organic matter to the tailings. It will also protect the surface from wind and water erosion and provide protected micro sites for more desirable species to establish. The nurse crop seed mix will consist of a mixture of species which will establish in the current mesic moisture regime, but will not persist as the tailings dry to a more xeric condition typical of the surrounding area.

#### 4.F.f Slimes Final Crop Species

The slimes final crop species were selected based on their tolerance to silt and clay textures and annual precipitation of 13 inches or less, corresponding to long-term, post-closure conditions. The extent to which seeding with the final crop species is required will depend on the degree of natural succession that occurs on the tailings during the drying and consolidation period. Unless acceptable vegetation species adapted to the anticipated long-term conditions become established relatively quickly through natural succession, seeding with the final slimes species mix will need to be performed to ensure permanent vegetation survival.

#### 4.F.g Sand Beach and Spillway Pool Species

The sand beach species were selected based on their tolerance to sandy textures and annual precipitation of 13 inches or less. The spillway pool species were selected based on their tolerance to standing water or riparian areas. These species have all been identified as native to the area or having commercially available cultivators adapted to site conditions.

#### 4.F.h Potential Amendments

When the tailings have dried to the point where they can support heavy equipment, the nurse crop will be tilled in and the tailings will be seeded with a seed mixture consisting of species selected from the test plots. Fertilizer and other amendment rates will be determined based on the nutrient status of the tailings at the time of seeding and test plot results.

Based on the current nutrient status of the tailings, the following fertilizer and amendments would be required to sustain a permanent vegetation cover:

| Sands | Slimes |
|---|---|
| 60 pounds $P_2O_5$ /acre | None |
| 40 pounds $K_2O$ /acre | 40 pounds $K_2O$ /acre |
| 40 pounds N/acre | 40 pounds N/acre |
| 10 tons O.M./acre | 10 tons O.M./acre |

These recommendations are based on the tailings laboratory data discussed earlier. Specific amendment recommendations will be developed prior to reclamation and be based on results of test plots and nutrient analysis performed immediately prior to reclamation. The O.M. recommendation is based on the assumption that the current O.M. content is negligible. Although the laboratory results indicate about 1 percent O.M., iron is known to interfere with the laboratory analysis resulting in positive errors (Lee 1939). The laboratory results indicate significant concentrations of iron. The O.M. amendment rate has been formulated to raise the O.M. level by approximately 1 percent. O.M. sources may include:

* sewage sludge
* hay or straw
* manure
* sawdust or sawmill scraps
* commercial organic fertilizers, such as Biosol
* nurse crop/green manure

A nurse crop is the most effective and cost-efficient technique to add O.M. to the tailings and help to ensure long-term survival of the permanent vegetation mix. The proposed nurse crop presented in Section 9.4 will provide a portion of the required O.M. Test plots during the mine life will determine the suitability of nurse crop species and the amount of soil O.M. contributed by the nurse crop. The final O.M. application rate will be determined to provide a rate comparable to natural soils in the area.

The ratio of carbon to nitrogen in the soil affects the rate of organic matter breakdown and nitrogen availability. As a general rule, at a C:N ratio of about 20:1 or less there is usually a net release of mineral nitrogen. At higher ratios, decomposition of organic material is slowed and nitrogen is used by soil microorganisms to decompose O.M., making the nitrogen unavailable to plants. Therefore, the final nitrogen fertilization rate will depend on the amount and type of O.M. added, since various O.M. materials have widely differing C:N ratios.

Phosphorus, K and O.M. should be added to the soil and, if possible, incorporated at least one month prior to seeding to allow P and K to contact the root zone and decomposition of the O.M. to begin prior to seeding. Excess fertilization with inorganic nitrogen will encourage establishment of weedy species which compete with the desired species. Therefore, nitrogen should be added in the spring following a fall seeding to reduce competition during initial establishment.

#### 4.F.i Final Seedbed Preparation

Once the tailings surface has dried enough to be trafficked by agricultural equipment, the seedbed should be prepared by ripping with a chisel plow or similar implement to a depth of approximately 6 inches. This step may be eliminated, modified, or restricted to certain areas of the TSF if significant permanent-type vegetation has already become established on the tailings as a result of earlier aerial or hydraulic seeding efforts and natural succession. Ripping loosens the soil surface and reduces resistance to seedling emergence and root growth. It also provides a roughened surface which reduces wind and water erosion and provides protected micro-sites for seedling establishment.

#### 4.F.j Seeding

Seeding and planting should be planned for early fall to take advantage of winter and spring precipitation. Exposed beaches will be sprayed each spring with the specified hydro mulch. Seed may be broadcast or drill-seeded. Drill seeding places the seed to a specified depth and covers it with soil. Broadcast seeding scatters the seed on the surface. Seeds are broadcast by dry methods or wet methods using a hydro seeder. Dry methods include centrifugal broadcasters, blowers or aircraft. Drill seeding is generally considered the superior method for arid and semi-arid sites. It assures that seed is distributed uniformly, at the proper rate and covered to the proper depth for germination. The drill seeder allows placement of different size seeds at the appropriate depth. One disadvantage of drill seeding is that the seeds are planted in straight rows resulting in a less natural appearance than for broadcast seeding. If broadcast seeding is used the seed is susceptible to predation by birds and small mammals, loss from wind, and some seeds may not adequately contact the soil.

### 4.G. Interim Reclamation and Test Plots

The following three tests are suggested to be conducted in test plots completed during the TSF's operational life:

1. Test capillary rise by depositing slimes and allowing them to dry. Samples will be collected annually to determine if salts will migrate and accumulate at the surface.

2. Test various organic amendments, fertilizer rates, mulches and species to determine an optimum mix for reclamation. Tests would be performed on samples of wet slimes (to simulate conditions at closure) and drained slimes and sands.

3 Samples of plant tissue will be collected and analyzed for copper and molybdenum concentrations to determine the potential for molybdenosis.

The tailings can be applied to the test area hydraulically. This will eliminate the need to mechanically transport material which has been deposited in the TSF.

### 4.H. Post Reclamation Maintenance and Monitoring

There are no specific reclamation success criteria in the BLM regulations. DOGM regulations (Rule 6474-111.13) require that revegetation achieve 70 percent of the premining vegetative ground cover and survive three growing seasons. If the pre-mining ground cover is unknown, the ground cover of an adjacent undisturbed area that is representative of the pre-mining ground cover can be used as a standard. Monitoring will begin the first fall after seeding is completed. Monitoring will include evaluating:

* erosion control
* noxious weed control
* vegetation success

Vegetation success monitoring will begin the first year following seeding. Monitoring for the first and second years will consist of a visual inspection of the seeded areas to identify areas where vegetation has not established. Any bare areas larger than 100 ft x 100 ft identified will be reseeded and/or amended as necessary.

Quantitative vegetation success monitoring will be estimated along a series of transects designed to representatively and evenly sample the tailings surface and an adjacent representative undisturbed area. Transects will be added until a statistically adequate sample size is determined. Sample adequacy will be determined using species-area curves. Annual monitoring will continue until results indicate vegetative cover on the tailings is 70 percent of the reference area. If the standard has not been achieved within 8 years after final seeding, SF Phosphates will request that the DOOM issue a determination that the revegetation work has been satisfactorily completed within practical limits.

Erosion control monitoring will be performed coincident with vegetation success monitoring and following significant precipitation events. Significant precipitation events are defined as at least one-half the intensity of the 10-year, 24-hour storm event.

Soil stability will be estimated for all reclaimed areas using the qualitative descriptors listed in Table 13 (NRC 1994). A qualified technician will observe each reclaimed area and assign one of the listed qualitative descriptors. The monitoring results will be used to aid in determining the cause of any failures which are encountered and to locate problem areas before erosion becomes widespread enough to affect water quality.

Any reclaimed area larger that 100 feet by 100 feet receiving an evaluation score (Table 13) of Class 3 or lower which persists more that 1 year will be investigated. Areas receiving a score of Class 2 or lower will receive treatment to correct the erosion immediately. If the vegetative cover, riprap, or other erosion control measure is found to be inadequate, the measures will be redone. Any obvious reasons for the failure will be noted and rectified. Climatic data for the time periods involved will also be considered while making a determination of the cause of failure.

Noxious weed monitoring will be performed during revegetation success monitoring. Prior to reclamation, a list of noxious weeds will be obtained from the local noxious weed control authority, if available. If noxious weeds are observed, appropriate measures will be taken to eradicate them. Species of concern, include:

- cheat grass (Anasantha tinctorum)
- tamarisk (Tamarix spp.)
- Russian olive (el.aeagnus angustifolia)

Noxious weed monitoring will continue until revegetation success criteria have been met.

## 5.0 STATEMENT OF RECLAMATION AND CLOSURE RESPONSIBILITY

SF Phosphates accepts responsibility for the reclamation and hazard abatement of the surface area affected by the mining and milling operations. Methods to be used to ensure successful reclamation were summarized in Section 4. These methods will include Best Management Practices and other techniques approved by regulatory agencies.

## 6.0 RECLAMATION COSTS

The following information provides costs and supporting documentation that will be the basis for establishing a reclamation bond as required by the BLM's bonding policy and the Utah Division of Oil, Gas and Mining (DOGM). These calculations are based upon the area on land (35 acres) administered by the BLM. They are estimated using the Means Heavy Construction Cost Data, 12th Annual Edition. Since specific details of the reclamation will be determined as the operation progresses, for example the exact seed mix, these calculations are intended to be very conservative.

Means 029 308 4600 - Slope mix,6#/M.S.F. Hydroseeding with mulch and fertilizer - $2,026 /acre

35 acres x $2,026 = $70,910 + 10% (Administration fees) = $ 78,000

The proposed reclamation cost is $ 78,000. Administrative fees are calculated at 10% as required by the BLM. Administrative costs include administration, engineering specifications and plans, permits, utilities, insurance, legal fees, and travel costs.

Based upon the Memorandum of Understanding (MOU) between BLM and DOGM, it is desired that one bond for the entire operation be placed with DOGM. Specific language for the amount calculated herein to protect the public lands would be included.

## 7.0 PUBLIC SAFETY

The operating and reclamation procedures outlined in this Plan of Operations are designed to insure a safe, stable environment that provides for the highest degree of public safety. All safety procedures implemented will be in accordance with the requirements by the Utah Division of Oil, Gas and Mining.

The proposed tailings dam expansion has been designed with adequate freeboard to contain the runoff from the upland watershed during a probable maximum precipitation event (PMP) of 8.9 inches. Total PMP runoff from the watershed was calculated to be 1,986-acre feet which would be safely contained within the impoundment at all times with no discharge. A minimum additional freeboard of 3 feet would be maintained at all times for wave action and embankment settlement.

The current embankment piezometric monitoring for the existing tailings dam consists of three standpipe piezometers that are monitored monthly. These will be extended up through the future raises so this monitoring can continue for the duration of impoundment operations.

For the new raises, piezometers are proposed to be placed in the cycloned sand beach to monitor the piezometric levels within the sands. They will be monitored monthly during impoundment operations

Five settlement monuments are proposed to be constructed on the downstream crest of the embankment at the completion of each raise. The settlement monuments will be steel plates placed in concrete which will be surveyed every 6 months during the TSF life to provide information on embankment settlement.

**Millsite Claims Summary**

| Mill Site Claim Name | BLM Serial Number |
|---|---|
| TB 1 | UMC 60082 |
| TB 3-7 | UMC 60084-60088 |
| TB 10-13 | UMC 60091-60094 |
| TB 16-19 | UMC 60097-60100 |
| TB 23-27 | UMC 60104-60108 |
| TB 32-35 | UMC 60113-60116 |
| TB 43-46 | UMC 60124-60127 |
| TB 54-57 | UMC 60135-60138 |
| TB 79 | UMC 60160 |
| TB 86 | UMC 60167 |
| TC 1-77 | UMC 60266-60342 |
| B 1-12 | UMC361669-680 |
| B 12A | UMC361681 |
| B 13-42 | UMC361682-711 |
| B 44-63 | UMC361713-732 |
| B 66-279 | UMC361735-948 |
| SF 1-9 | |
| SF 9a | |
| SF 10-16 | |

# TABLE 7

## NUTRIENT ANALYSES LABORATORY RESULTS
## SF PHOSPHATES TAILINGS

| | Location | | | | | | Critical |
|---|---|---|---|---|---|---|---|
| | Tails Sand #1 | Sand #2 | Sand #3 | Tails Slime #1 | Slime #2 | Slime #3 | Value |
| pH | 7.2 | 7.0 | 7.1 | 7.2 | 7.2 | 7.2 | <5.0 or >8.5 |
| EC (mmhos/cm @ 25° C) | 1.79 | 2.63 | 2.20 | 2.65 | 2.71 | 2.62 | >8 |
| Saturation (%) | 34.9 | 30.3 | 31.9 | 37.3 | 37.0 | 34.6 | <25 or >80 |
| Calcium (meq/l) | 14.5 | 24.5 | 23.2 | 24.2 | 24.4 | 23.2 | --- |
| Magnesium (meq/l) | 5.33 | 8.67 | 3.90 | 8.31 | 8.88 | 8.58 | --- |
| Sodium (meq/l) | 1.20 | 1.27 | 0.52 | 1.75 | 1.87 | 1.77 | --- |
| SAR | 0.38 | 0.31 | 0.14 | 0.43 | 0.46 | 0.44 | >10 |
| Sand (%) | 84.0 | 81.0 | 84.0 | 26.0 | 20.0 | 28.0 | --- |
| Silt (%) | 8.0 | 10.0 | 6.0 | 64.0 | 71.0 | 61.0 | --- |
| Clay (%) | 8.0 | 9.0 | 10.0 | 10.0 | 9.0 | 11.0 | --- |
| Texture | loamy sand | loamy sand | loamy sand | silt loam | silt loam | silt loam | --- |
| Organic Matter (%) | 0.8 | 0.9 | 0.9 | 1.2 | 1.3 | 1.2 | <1 |
| CEC (meq/100 g) | 5.28 | 4.56 | 6.12 | 7.00 | 6.22 | 6.54 | --- |
| ***Plant Available*** | | | | | | | |
| P (ppm) | 3.80 | 2.54 | 2.20 | 14.8 | 12.5 | 13.5 | <7 |
| K (ppm) | 94.0 | 87.0 | 68.0 | 82.0 | 84.0 | 82.0 | <120 |
| Nitrate-Nitrogen (ppm) | 1.24 | 1.04 | 0.92 | 0.74 | 0.50 | 0.48 | <10 |
| Copper (ppm) | 0.24 | 0.34 | 0.32 | 0.46 | 0.46 | 0.46 | --- |
| Lead (ppm) | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | --- |
| Arsenic (ppm) | 0.44 | 0.36 | 0.21 | 0.45 | 0.44 | 0.46 | --- |
| Boron (ppm) | 0.17 | 0.24 | 0.13 | 0.20 | 0.22 | 0.23 | <0.5 or >5 |
| Selenium (ppm) | 0.02 | 0.02 | <0.02 | 0.02 | 0.02 | 0.02 | >0.1 |
| Molybdenum (ppm) | 0.66 | 0.71 | 0.73 | 0.66 | 0.63 | 0.71 | 0.5 - 1.0 |
| Iron (ppm) | 13.2 | 16.4 | 9.0 | 50.4 | 44.8 | 54.0 | --- |
| Manganese (ppm) | 0.60 | 1.04 | 1.16 | 2.18 | 1.88 | 1.98 | --- |
| Zinc (ppm) | 0.46 | 1.48 | 5.10 | 0.64 | 0.60 | 0.62 | <1.0 |
| ***Total Metals*** | | | | | | | |
| Total Boron (ppm) | 27.2 | 18.7 | 21.8 | 19.4 | 14.9 | 14.0 | --- |
| Total Arsenic (ppm) | 19.4 | 27.0 | 26.1 | 18.1 | 18.9 | 19.1 | 20 - 50 |
| Total Copper (ppm) | 13.8 | 20.6 | 18.3 | 19.4 | 18.4 | 19.5 | 60 - 120 |
| Total Lead (ppm) | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | 7.49 | 100 - 400 |
| Total Molybdenum (ppm) | 5.43 | 5.40 | 5.94 | 4.97 | 4.98 | 5.99 | 2 - 10 |
| Total Selenium (ppm) | 3.29 | 6.38 | 5.60 | 5.52 | 5.55 | 5.68 | 5 - 10 |
| Total Iron (ppm) | 9,930 | 15,100 | 14,500 | 9,440 | 9,720 | 10,300 | --- |
| Total Manganese (ppm) | 83.0 | 81.5 | 87.1 | 174 | 172 | 168 | --- |
| Total Zinc (ppm) | 162 | 170 | 179 | 109 | 110 | 108 | 70 - 400 |
| Total Kjeldahl (Nitrogen %) | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | --- |

Notes:

Critical values were determined from a review of the available literature and represent values above which toxicity may result and below which deficiencies many result. However, these levels can vary significantly as a function of plant species, soil pH, texture, and may other features.

## TABLE 8

## ACID-BASE ACCOUNTING RESULTS
## SF PHOSPHATES TAILINGS

| | Location | | | | | |
|---|---|---|---|---|---|---|
| | Tails Sand #1 | Sand #2 | Sand #3 | Tails Slime #1 | Slime #2 | Slime #3 |
| Carbonate % | 12.4 | 12.1 | 12.2 | 13.8 | 13.9 | 13.7 |
| Total Sulfur % | 0.93 | 1.89 | 1.73 | 1.22 | 1.17 | 1.21 |
| T.S. AB t/1000t | 29.1 | 59.0 | 54.0 | 38.1 | 36.6 | 37.8 |
| Neut. Pot. t/1000t | 127 | 125 | 128 | 136 | 142 | 106 |
| T.S. ABP t/1000t | 98.0 | 65.5 | 73.6 | 97.5 | 106 | 98.8 |

Note: T.S.=Total Sulfur
AB-Acid Base
Neutr. Pot.=Neutralization Potential
ABP=Acid Base Potential=Neut. Pot.-T.S. AB

## TABLE 9

## POTENTIAL RECLAMATION SPECIES SLIMES NURSE CROP

| Scientific Name | Common Name |
|---|---|
| *Grass* | |
| Agropyron cristatum | crested wheatgrass |
| Alopecurus arundinaceus | creeping meadow foxtail |
| Bromus biebersteinii | meadow brome |
| Dactylis glomerata | orchardgrass |
| Elymus trachycaulus | slender wheatgrass |
| Elytrigia intermedia | pubescent wheatgrass |
| Elytrigia pontica | tall wheatgrass |
| Festuca arundinacea | tall fescue |
| Muhlenbergia wrightii | spike muhly |
| Pascopyrum smithii | western wheatgrass |
| Phalaris arundinacea | reed canarygrass |
| Psathyrostachys juncea | Russian wildrye |
| Pseudoreogneria spicata inermis | beardless wheatgrass |
| Stipa viridula | green needlegrass |
| *Forb* | |
| Astragalus cicer | cicer milkvetch |
| Coronilla varia | crownvetch |
| Erodium circutarium | alfileria |
| Lotus corniculatus | birdsfoot trefoil |
| Medicago sativa | alfalfa |
| Melilotus alba | white sweetclover |
| Melilotus officinalis | yellow sweetclover |
| Onobrychis viciafolia | sainfoin |
| Penstemon strictus | Rocky Mountain penstemon |
| Sphaeralea coccinea | scarlet globemallow |
| Vicia americana | American vetch |

## TABLE 10

## POTENTIAL RECLAMATION SPECIES FINAL COVER-SLIMES

| Scientific Name | Common Name |
|---|---|
| *Grass* | |
| Agropyron cristatum | crested wheatgrass |
| Agropyron desertorum | standard crested wheatgrass |
| Agropyron Riparium | streambank wheatgrass |
| Athentherum hymenoides | Indian ricegrass |
| Elymus lanceolatus | thickspike wheatgrass |
| Hilaria jamesii | galleta |
| Pascopyrum smithii | western wheatgrass |
| Phalaris arundinacea | reed canarygrass |
| Psathyrostachys juncea | Russian wildrye |
| Sporobolus airoides | alkali sacaton |
| Sporobolus cryptandrus | sand dropseed |
| *Forb* | |
| Clematis ligusticifolia | virginsbower |
| Erodium cicutarium | alfileria |
| Kochia prostrata | prostrate summer cypress |
| Melilotus alba | white sweetclover |
| Melilotus officinalis | yellow sweetclover |
| Sphaeralcea coccinea | scarlet globemallow |
| *Shrub* | |
| Artemisia arbuscula nova | black sagebrush |
| Artemisia cana | silver sagebrush |
| Artemisia tridentata | big sagebrush |
| Atriplex canescens | fourwing saltbush |
| Atriplex nuttallii | Nuttall saltbush |
| Atriplex polycarpa | desert saltbush |
| Caragana arborescens | Siberian peashrub |
| Chrysothamnus nauseosus | rubber rabbitbrush |
| Cowania mexicana | cliffrose |
| Eurotia lanata | winterfat |
| Juniperus osteosperma | Utah juniper |
| Purshia tridentata | antelope bitterbrush |
| Rhus trilobata | skunkbush sumac |

## TABLE 11

## POTENTIAL RECLAMATION SPECIES SAND BEACH

| Scientific Name | Common Name |
|---|---|
| *Grass* | |
| Achnetherum hymenoides | Indian ricegrass |
| Agropyron fragile | Siberian wheatgrass |
| Agropyon riparium | streambank wheatgrass |
| Elymus trachycaulus | pubescent wheatgrass |
| Leymus racemosus | mammoth wildrye |
| Sporobolus airoides | alkali sacaton |
| Sporobolus contractus | spike dropseed |
| Sporobolus cryptandrus | sand dropseed |
| Stipa comata | needle and thread |
| *Shrub* | |
| Atriplex canescens | fourwing saltbrush |
| Atriplex nuttallii | Nuttall saltbush |
| Atriplex polycarpa | desert saltbrush |
| Caragana arborescens | Siberian peashrub |
| Chrysothamnus nauseosus | rubber rabbitbrush |
| Cowania mexicana | cliffrose |
| Ephedra viridis | green ephedra |
| Juniperus osteosperma | Utah juniper |

## TABLE 12

## POTENTIAL RECLAMATION SPECIES POND AREA

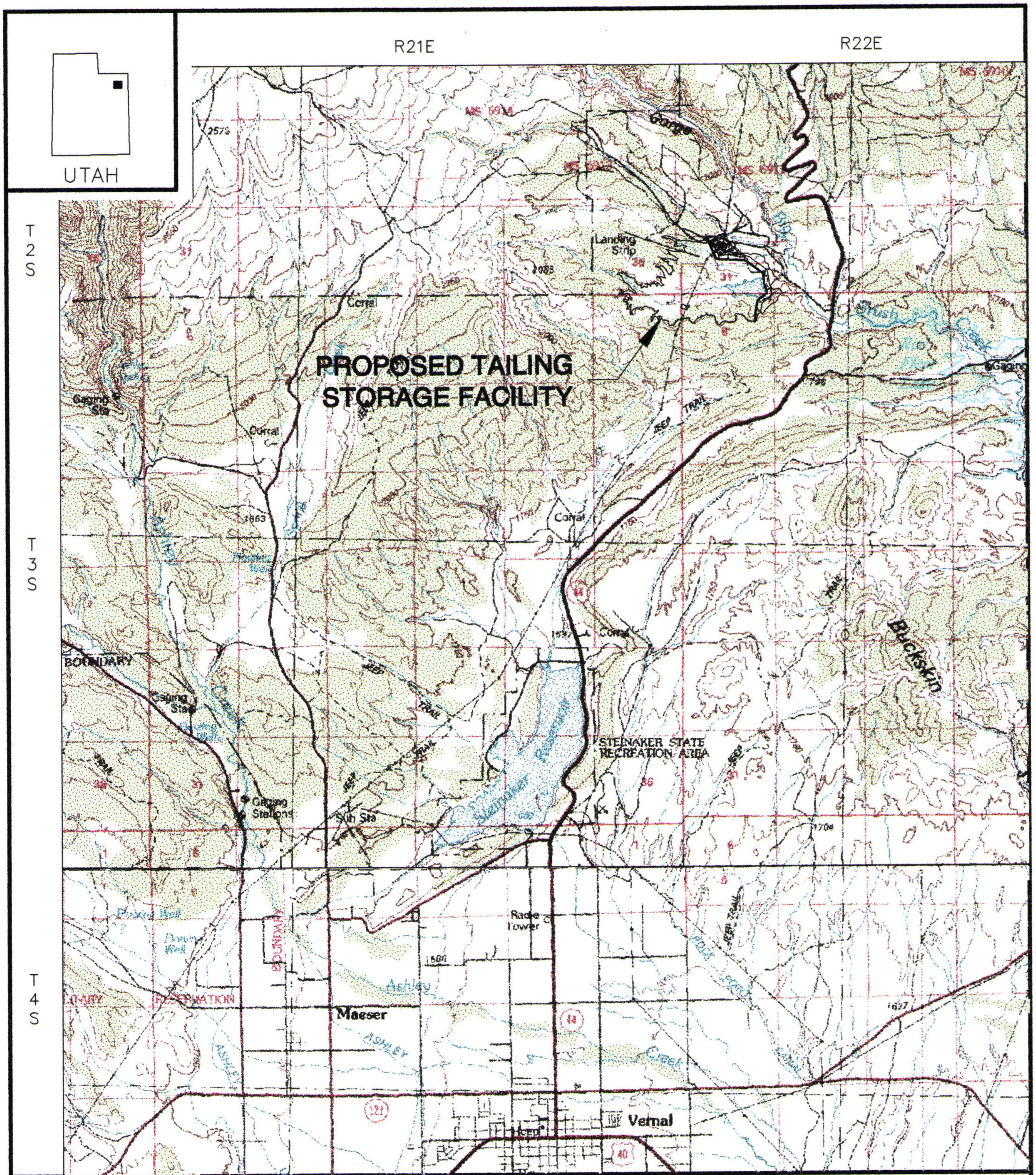
| Scientific Name | Common Name |
|---|---|
| *Grass* | |
| Deschampsia caespitosa | tufted hairgrass |
| Distichlis stricta | inland saltgrass |
| Juncus spp. | rush |
| Muhlenbergia asperifolia | alkali muhly |
| Poa palustris | fowl bluegrass |
| Scirpus americanus | american bulrush |
| Typha latifolia | common cattail |
| *Forb* | |
| Dodecatheon pulchellum | shooting star |
| Iris missouriensis | Rocky Mountain iris |
| Mertensia cilata | mountain bluebells |
| Mimulus spp. | monkey flower |
| Oenothera hookeri | Hooker evening prinrose |
| Potentilla anserina | silverweed cinquefoil |
| Ranunculus repens | creeping buttercup |
| *Shrubs/Trees* | |
| Acer glabrum | mountain maple |
| Acer grandidentata | big tooth maple |
| Acer negundo | boxelder maple |
| Alnus tenuifolia | thinleaf alder |
| Cornus stolonifera | redosier dogwood |
| Populus tremuloides | quaking aspen |
| Prunus emarginata | bitter cherry |
| Prunus virginiana | chokecherry |
| Ribes aureum | golden currant |
| Salix bebbiana | bebb willow |
| Salix exigua | coyote willow |
| Sambucus coerulea | blueberry elder |
| Shepherdia argentea | silver buffaloberry |

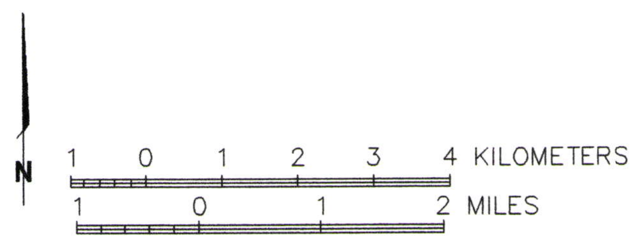
## TABLE 13

## QUALITATIVE DESCRIPTORS OF SOIL SURFACE STATUS

| Characteristic | Class 1 | Class 2 | Class 3 | Class 4 | Class 5 |
|---|---|---|---|---|---|
| Soil movement | Subsoil exposed over much of area; may have embryonic dunes and wind-scoured depressions | Soil and debris deposited against minor obstructions | Moderate movement of soil is visible and recent; slight terracing | Some movement of soil particles | No visual evidence of movement |
| Surface rock and/or litter | Very little remaining (use care on low-productivity sites); if present, surface rock or fragments exhibit some movement and accumulation of smaller fragments behind obstacles | Extreme movement is apparent; large and numerous deposits against obstacle; if present, surface rock or fragments exhibit some movement and accumulation of smaller fragments behind obstacles | Moderate movement is apparent and fragments are deposited against obstacles; if present, fragments have a poorly developed distribution pattern | May show slight movement; if present, coarse fragments have a truncated appearance or spotty distribution caused by wind or water | Accumulation in place; if present, the distribution of fragments shows no movement caused by wind or water |
| Pedestaling | Most rocks and plants are pedestaled and roots are exposed | Rocks and plants on pedestals are generally evident; plant roots are exposed | Small rock and plant pedestals occurring in flow patterns | Slight pedestaling, in flow patterns | No visual evidence of pedestaling |
| Flow patterns | Flow patterns are numerous and readily noticeable; may have large barren fan deposits | Flow patterns contain silt, sand deposits, and alluvial fans | Well defined small, and few with intermittent deposits | Deposition of particles may be in evidence | No visual evidence of flow patterns |
| Rills and gullies | May be present at depths of 8 to 15 cm (3 to 6 inches) and at intervals of less than 13 cm (15 inches); sharply incised gullies cover most of the area, and 50 percent are actively eroding | Rills at depths of 1 to 15 cm (0.5 to 6 inches) occur in exposed areas at intervals of 150 cm (5 feet); gullies are numerous and well developed, with active erosion along 10 to 50 percent of their lengths or a few well-developed gullies with active erosion along more than 50 percent of their length | Rills at depths less than 15 cm occur in exposed places at intervals of less than 300 cm (10 ft); gullies present, with active erosion along less than 10 percent of their length; some vegetation may be present | Some rills in evidence at infrequent intervals of over 300 cm (10 feet); evidence of gullies that show little bed or slope erosion; some vegetation is present on slopes | No visual evidence of rills; may be present in stable condition; vegetation on channel bed and side slopes |

SOURCE: Adapted from U.S. Department of the Interior, Bureau of Land Management. 1973 Determination of Erosion Condition Class, Form 7310-12. May. Washington, D.C.: U.S. Department of the Interior




# SF PHOSPHATES LTD. CO.

## VERNAL, UTAH

FIGURE 1
LOCATION MAP

jbr environmental consultants, inc.
Salt Lake City, Utah Cedar City, Utah Reno, Nevada Elko, Nevada

| DESIGN BY | BB | DRAWN BY | CP | CH'D BY | | SCALE 1:100000 |
|---|---|---|---|---|---|---|

DATE DRAWN 5/1/98

REVISION

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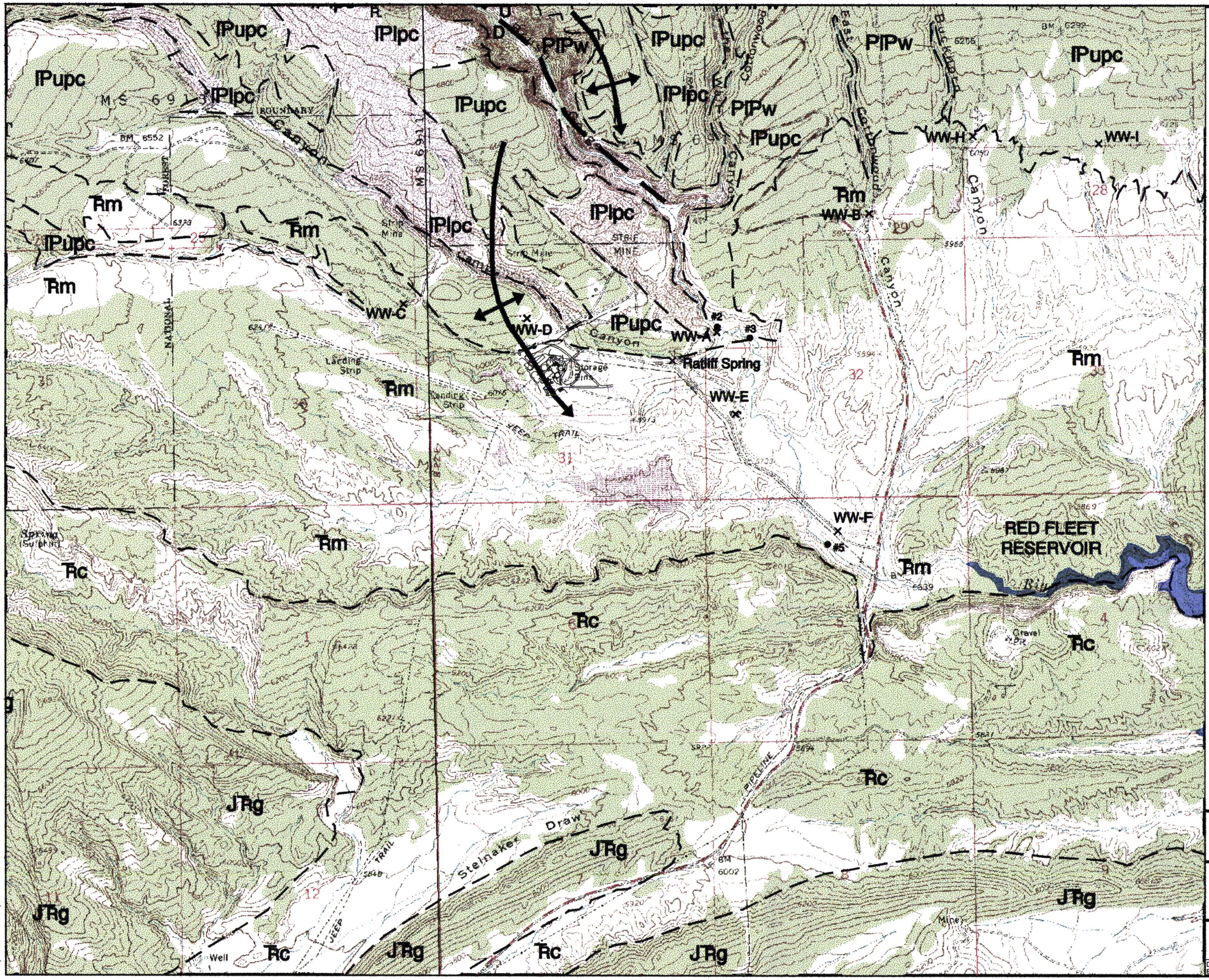



## EXPLANATION

| | | |
|---|---|---|
| JURASSIC | JTRg | GLEN CANYON SANDSTONE |
| TRIASSIC | TRc | CHINLE FORMATION |
| | TRm | MOENKOPI FORMATION |
| PERMIAN | IPupc | UPPER PARK CITY FORMATION |
| | IPlpc | LOWER PARK CITY FORMATION |
| PENNSYLVANIAN AND PERMIAN | PIPw | WEBER FORMATION |

CONTACT

FAULT

ANTICLINE

x WW-E WATER WELL LOCATION

N

2000 0 2000 FEET

REF: (1) Chevron Chemical, (2) State of Utah–Dept. of Natural Resources Technical Publication No. 53 1976.

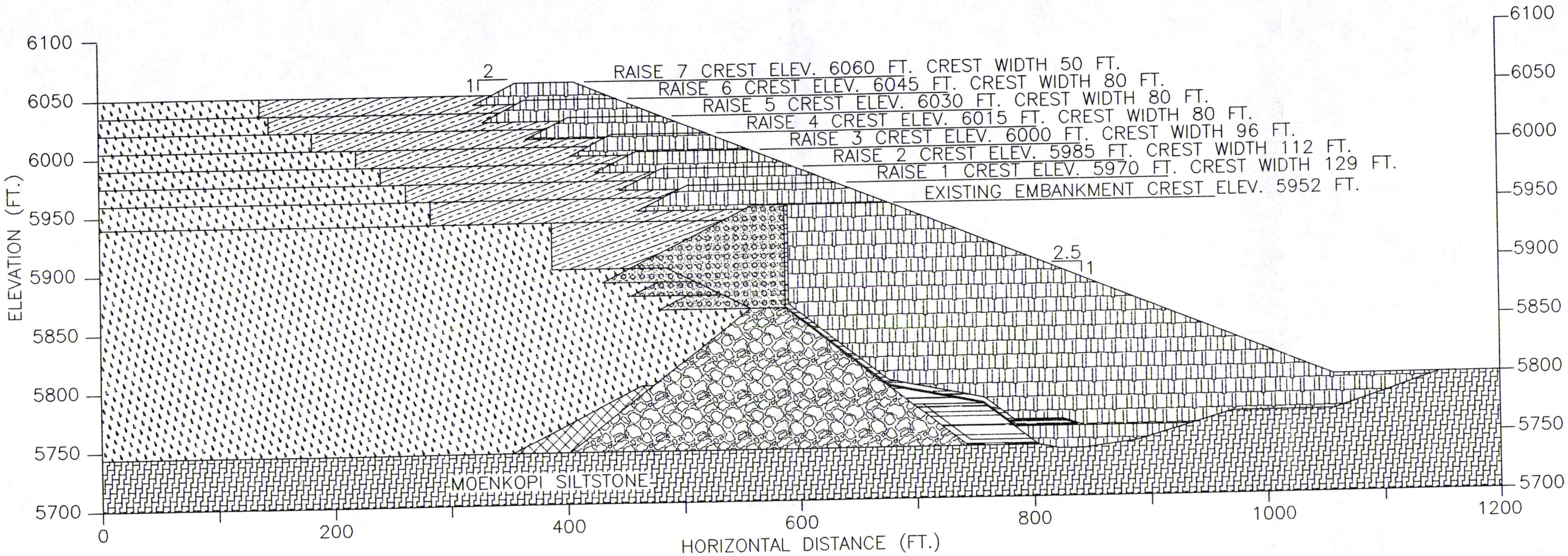
**SF PHOSPHATES LTD. CO.**
**VERNAL, UTAH**

FIGURE 3
GEOLOGY MAP

jbr environmental consultants, inc.
Salt Lake City, Utah Cedar City, Utah Reno, Nevada Elko, Nevada

| DESIGN BY | DRAWN BY | CH'D BY | SCALE | DATE DRAWN / REVISION |
|---|---|---|---|---|
| RB | CP | | 1"=2000' | 5/1/98 |
| | | | | 5/20/98 |
| | | | | 6/13/98 |

I:\SF_PHOS\SF5-3A.DWG




LEGEND

- DRAINAGE LAYER
- CYCLONED SANDS
- TAILING SLIMES
- MOENKOPI SILTSTONE
- MINE WASTE ROCK
- SILT BLANKET
- MINE WASTE ROCK AND TAILINGS
- COMPACTED TAILINGS SAND

NOTE

1. TYPICAL EMBANKMENT SECTIONS BASED ON INFORMATION PRESENTED IN MORRISON-KNUDSEN ENGINEERS, INC. (AUGUST, 1995) AND KNIGHT PIESOLD (APRIL, 1996).

**SF PHOSPHATES LTD. CO.**
**VERNAL, UTAH**

FIGURE 4
TAILINGS DAM CROSS SECTION

jbr environmental consultants, inc.
Salt Lake City, Utah Cedar City, Utah Reno, Nevada Elko, Nevada

| DESIGN BY | DRAWN BY | CH'D BY | SCALE | REVISION | DATE DRAWN |
|---|---|---|---|---|---|
| GA | GA | | 1"=100' | | 5/1/98 |
| | | | | | 5/20/98 |

SF5-6

This page is a reference page used to track documents internally for the Division of Oil, Gas and Mining

Mine Permit Number M0470007 Mine Name Vernal Phosphate
Operator SF Phosphate Company Date August 21, 1998
TO ______________________ FROM ______________________

__CONFIDENTIAL __BOND CLOSURE __LARGE MAPS X EXPANDABLE
__MULTIPUL DOCUMENT TRACKING SHEET __NEW APPROVED NOI
__AMENDMENT _OTHER ______________________

Description YEAR-Record Number

__NOI X Incoming __Outgoing __Internal __Superceded

Tailings Storage Facility Expanson

___NOI __Incoming __Outgoing __Internal __Superceded

__NOI __Incoming __Outgoing __Internal __Superceded

__NOI __Incoming __Outgoing __Internal __Superceded

__TEXT/ 81/2 X 11 MAP PAGES __11 X 17 MAPS __LARGE MAP

COMMENTS: ______________________

CC: ______________________